

Taking Geocoder to Work

Making Geocoder part of your Daily Routine

Alexander J. MacDonald, CARIS

Corey Collins, CARIS

Contact: alex.macdonald@caris.com

Abstract

For many years the focus has been on collecting and processing the first bottom return of multibeam sonars. However, the acoustic backscatter acquired by multibeam sonars, as well as side scan sonars, also carries important information about the seafloor and its physical properties. This information provides valuable data to aid in seafloor classification, and important auxiliary information for a bathymetric survey. One necessary step towards this characterization is the creation of more consistent and reliable mosaics of acoustic backscatter. For that, it is necessary to carry out certain corrections on the backscatter to create this final backscatter map. With the integration of the tools found in Geocoder such as radiometric corrections, geometric corrections and mosaic blending, SIPS is able to create high-quality, accurate mosaics. Seafloor classification, Reson Snippet support and improved Simrad support have also been leveraged from Geocoder.

Geocoder's strengths are certainly in its array of detailed backscatter corrections and its accurately modeled seafloor characterization algorithms. The challenge then is to blend these capabilities into a coherent workflow, design a clear yet powerful user interface, and provide the scalability, stability and efficiency needed by organizations of any size.

Realizing that different users have different needs, HIPS & SIPS employs a variety of options for incorporating these new capabilities into existing workflows. In order to allow users to absorb the changes at their own pace, the traditional workflows are still available. They are now augmented, however, by a sleek, highly automated, full survey approach. This is made possible by combining the re-designed SIPS Template Wizard and the all-new Mosaic Editor with the processing power of Geocoder.

SIPS Template Wizard allows users to take raw imagery data all the way to fully corrected, mosaicked lines with a few mouse clicks. Then, using Mosaic Editor the user is able to create a complete mosaic from the corrected, mosaicked lines. Mosaic Editor provides intuitive functionality for blending and adjusting, adding or removing data in order to produce the mosaic. Mosaic Editor also has a sediment analysis tool that allows users to interactively analyze and assess seafloor characteristics.

Embedding Geocoder deeply into the HIPS & SIPS code base has produced a synergism with numerous advantages. For instance, the core technology for the mosaics is based on HIPS BASE Surfaces, giving users a fast, reliable and familiar format for editing and storing their work. Also, system resource management can be directly controlled and improved upon, providing greater stability and scalability not available in Geocoder alone. Deep integration also allows Geocoder processing to be made faster, more efficient, and more flexible.

I. Overview

The embedding of Geocoder into CARIS HIPS and SIPS is nothing short of a new benchmark in backscatter processing. Geocoder contains advanced algorithms for radiometric and geometric backscatter corrections as well as sophisticated sediment angular response analysis capabilities. Geocoder was developed by Dr. Luciano Fonseca and is licensed by the University of New Hampshire.

Geocoder brings great benefits to SIPS on its own merits, but this union has in fact produced unique strengths that neither Geocoder nor SIPS can claim on their own. This result is by design and is the main purpose behind incorporating Geocoder in a commercial application. This section will provide an overview of the reciprocity between Geocoder and CARIS HIPS and SIPS before exploring the topics in more detail in the sections that follow.

Multibeam Backscatter Processing

Geocoder was purpose-built to process multibeam backscatter, both beam averaged intensity data and the higher resolution time series returns. As a result, HIPS and SIPS now supports Reson “snippet” data and has greatly improved support for Reson beam averaged data, Simrad beam averaged data, and Simrad time series data, all thanks to the inclusion of Geocoder as a processing engine.

Survey Approach

The traditional mode of processing imagery in a waterfall display, one line at a time, has its merits, but SIPS aims to promote greater efficiency by advocating a “whole survey approach”. Using SIPS’ new Mosaic Editor, users are encouraged to correct and geo-reference their survey data en masse, create a mosaic, then examine the data for anomalies requiring closer attention. SIPS Template Wizard may also be used in this way to help standardize operations through the use of process templates.

Sediment Analysis Tool

For some users of HIPS and SIPS, it is the inclusion of Geocoder’s sediment analysis engine that will be of key interest. The sediment analysis tool in Mosaic Editor allows users to analyze the angular responses of corrected data to determine the sediment type in that location. Perhaps less apparent is that this functionality also allows the sediment angular artifacts to be removed from empirically generated beam patterns – providing improved accuracy when correcting data for this effect.

With all that Geocoder has to offer, it may be difficult for some to imagine how integrating it with a commercial application such as HIPS and SIPS could create additional noteworthy advantages. The aim of this paper is to provide a detailed look at exactly how joining the two produces crucial new strengths that neither could claim otherwise.

II. Workflow Overview

It is important to give an overview of the new SIPS workflow (see Figure 1) and how it relates to the previous workflow, before going any further. The initial steps of conversion, bathymetric processing, and merging in HIPS are required before processing multibeam backscatter. This is essential for producing the geo-referenced data required to process certain types of data using Geocoder. On its own, Geocoder requires a separate GSF file to process such data, but the integration into HIPS and SIPS makes this unnecessary.

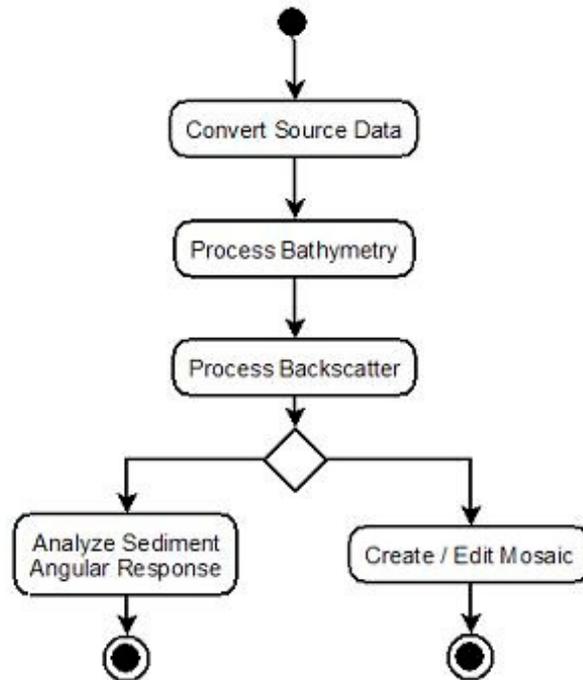


Figure 1: HIPS and SIPS Multibeam Imagery Workflow

Now that the data is prepared for backscatter processing, the user can choose to use the SIPS Template Wizard to process the survey data with a new or existing template; or they may decide to interact with the data more closely by using Mosaic Editor. In either case, the user corrects and geo-references their data. From here, the user may create a mosaic from some or all of the processed data, or they may choose to investigate the sediment properties of the lines using the Sediment Analysis Tool in Mosaic Editor.

To allow users time to adjust to the workflow and tool changes, the traditional workflow is still available but has a crossover point to the new workflow. Users may still process Side Scan data using Side Scan Editor. Following this, they enter Mosaic Editor to create their mosaics.

III. Survey Approach

From the workflow overview, we can see that the intention now is to have users perform all of their backscatter correction, analysis, and mosaicking in one place: Mosaic Editor. This is all part of a fundamental shift in SIPS methodology analogous to the impact of Subset Editor on HIPS. In this new model, the user is encouraged to process data using the Geocoder engine with its default settings, which produce geo-referenced, corrected data. The user next selects some or all of the processed data and creates a mosaic. The next step then is to examine the mosaic and determine if it warrants further work.

If there are areas of concern arising from inspection of the mosaic (or analysis of the sediment data using the SAT), the user may elect to examine the data more closely (see Figure 2). The geo-referenced, corrected data may provide the necessary clues to reprocess some or all of the data. If a deeper analysis is required, a time-based, waterfall style editor is integrated into Mosaic Editor. The waterfall editor is capable of ping-based editing, processing and analysis that will be immediately familiar to SIPS users. It features a Signal Display Window, contact editing tools, numerous correction tools and an area based zoom window.

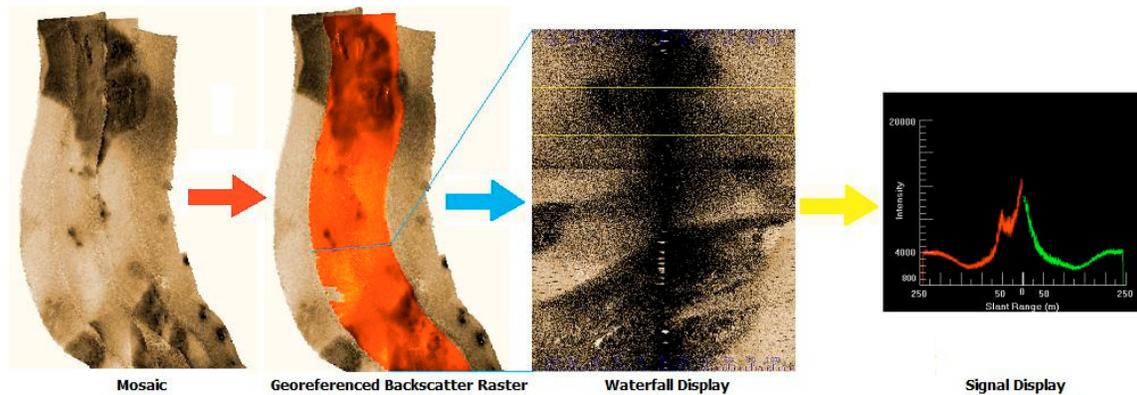


Figure 2: Levels of Investigation in a Survey Approach

IV. Geocoder Processing

To process source data with the Geocoder engine is to apply Dr. Fonseca’s suite of accurately modelled backscatter correction algorithms. Geocoder has numerous radiometric and geometric corrections, all of which are available to the user in SIPS. Generally speaking, due to the sophistication and reliability of Geocoder’s corrections, it is best to leave the default settings enabled. Due to the integration with HIPS and SIPS, raw source data need only be read and processed once, thus clearly offering a simple and efficient manner of processing data while taking full advantage of Geocoder’s abilities.

With the integration in SIPS, the output for Geocoder-processed data is stored in a new type of file called a GeoBaR (Geo-referenced, Backscatter Raster). GeoBaRs are central to Mosaic Editor and the new workflow. GeoBaRs use BASE Surface technology and share in all of the benefits of that technology such as data caching which helps provide scalability. With the introduction of CARIS’ new CSAR framework to BASE Surfaces, fully editable, gigapixel mosaics are now realizable.

Using GeoBaRs as Geocoder's output target provides another clear advantage: the ability to have many GeoBaRs per survey line. This can be very useful when dealing with file formats such as XTF which can have multiple sources of imagery data. The Reson XTF record, for instance, may have Beam Average Intensity, Side Scan, and Snippet data. Mosaic Editor allows the user to process all of these and even visually compare them if desired. Mosaic Editor also allows the user to process and store the data at different resolutions.

It may be prudent to note that this flexibility may present its own management issues with the number of mosaics and GeoBaRs being produced. Fortunately, since these are all actually BASE Surfaces, they can be stored in CARIS Bathy DataBase. This facilitates sharing of such data between different users, groups, or offices. It also provides other advantages like the ability to correlate mosaic imagery data with bathymetry data and the ability to restrict access to data based on user privileges.

V. Creating Mosaics

GeoBaRs are the prerequisite for creating any mosaic in SIPS. The conformity that this imposes actually provides significant new opportunities in SIPS. As noted, more than one GeoBaR may be created per line, permitting mosaics to be created from different types of source data and from various resolutions. Additionally, GeoBaRs from other surveys in the same geographical area may also be used in the creation of a mosaic. In this way, mosaics can be composited using survey data from various vessels, equipment, and logged data formats from any number of related surveys.

Creating mosaics in SIPS can be done in a variety of ways. Such diversity is useful since not all situations can be anticipated. However, there is a suggested workflow and associated tool set for mosaic creation that will be examined in this section.

First step: Select GeoBaRs for inclusion.

The GeoBaRs that are to be used as source data for the mosaic must be selected and loaded in Mosaic Editor. This is likely one of the times that the user will encounter the Conflict Resolution dialog, which helps automate the selection process. The Conflict Resolution dialog presents options to the user when survey lines are found to have multiple associated GeoBaRs. It allows the user to automatically select from the most recently created, finest resolution, or particular source data type. The user may opt to choose the GeoBaR manually as well using the auto-generated drop-down list. The user has the option to apply the automated decision logic to all conflicts at once, or may decide each one sequentially. Once the GeoBaRs are selected and loaded, they can be used to create a mosaic.

Second step: Create an initial mosaic

To create the initial mosaic, the user has a choice of three automated compositing algorithms: auto-seam, shine-through, and overwrite. Auto-seam uses a weighting scheme to determine which value is the most valid to display in overlapping regions. Shine-through uses the largest value from the set of possible values in a contested cell. Overwrite uses the draw order to determine the successful point. For the overwrite case, the effect of draw order can be seen before creating a mosaic. Controls have been provided on the edit panel to allow the user to raise

or lower the currently selected GeoBaR, i.e. change its Z-order, and see the result instantly. Gone is the multi-step Mosaic Wizard; to create mosaics now, a simple dialog is invoked where a few necessary parameters are entered.

It is important to note that it is not necessary to include all GeoBaRs in the mosaic at once, more may be added at any time using the Add to Mosaic function. If performing this step, there are two other combine types that may be used: underlay (opposite of overwrite) and default (uses the mosaic's combine method). GeoBaRs already included in a mosaic may be removed. These "Component GeoBaRs" may be removed using the Remove from Mosaic command and one of two options: Remove Complete and Remove Explicit. Remove Complete will re-mosaic the area covered by the Component GeoBaR being removed, but without data from this GeoBaR. Remove Explicit uses the Contributor layer to remove only those values that are explicitly listed as being from the GeoBaR being removed. This allows any blended points to remain in the mosaic.

Third step: Histogram editing and Blending

The histogram controls allow the user to adjust the target item's values by reshaping the histogram for that target. Individual GeoBaRs, Component GeoBaRs (those which are already part of a mosaic), and Mosaics may all be edited in this fashion. The intent of this control, and of all controls on this panel, is for the user to focus on the visual impact of their changes and not on the controls themselves. To this end, no numeric values have been used on this interface. All changes are made to the Current Intensity layer of the target, the Original Intensity layer always contains the originally processed data. The Current Intensity layer may be reset to the Original Intensity values if desired.

The Blend function is only available for Component GeoBaRs. This is the same blend function as is found in Geocoder and can be very effective. Changes made while using this function are stored on a temporary GeoBaR and may be applied to the mosaic or cancelled.

Fourth Step: Finish editing / Re-edit

When editing is complete, the user should exit the mosaic edit mode. The mosaic may be edited further at any time. When re-entering edit mode, all unloaded component GeoBaRs will be automatically reloaded and their draw order re-instated. This allows mosaic editing to be performed over multiple sessions.

VI. Sediment Analysis

One of the most innovative aspects of Geocoder is its sediment analysis capabilities. This is made possible by the accurate removal of acquisition artifacts found in the source data and by the sediment angular response models built into Geocoder. These models were implemented in Geocoder by Dr. Fonseca and are based on years of published research in this area. This is a crucial point, for it is these models that drive the analysis, rather than any sort of "curve fitting" algorithm. This powerful tool, known in Geocoder as ARA, is realized in SIPS as the Sediment Analysis Tool (SAT). The SAT was designed to provide the complete capabilities of Geocoder's ARA engine in an easy-to-use interface that accommodates the varying needs of SIPS users.

The Sediment Analysis Tool is composed of two main parts: a dockable, resizable SIPS graph window that displays the average angular response for a given range of data (see Figure 3), and an uncomplicated set of controls for initiating analysis or interacting with the backscatter models. The controls have both standard and advanced modes of operation.

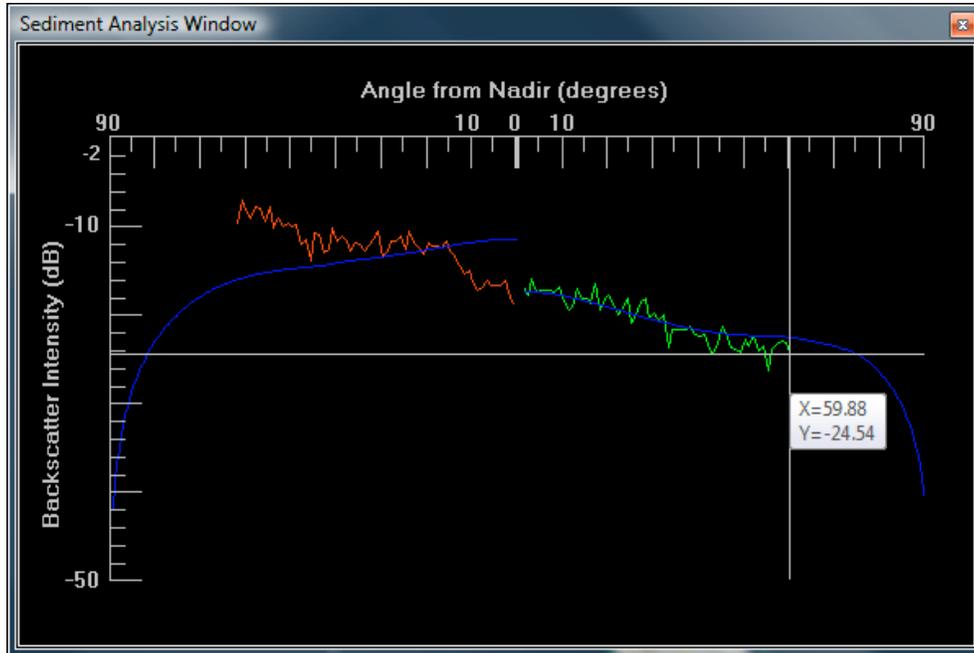


Figure 3: The Sediment Analysis Graph Window

The standard mode allows the user to analyze results for port and/or starboard returns. With a single click, Geocoder's sediment analysis engine springs into action, evidenced by the graph's visibly converging backscatter model traces. When the analysis is complete, the user may choose to view the model's parameter values for either port or starboard, or they may be satisfied with the provided textual result.

In the advanced mode, the user has the freedom to interact with the model, adjusting the parameters and seeing the graph's backscatter traces update automatically. Model parameters may be adjusted using either a single slider control or using a numeric entry box. At any point, the user may ask Geocoder to analyze the angular response they have entered to get Geocoder's corresponding textual representation.

As noted above, the sediment analysis graph plays an important part in both standard and advanced analysis modes. The graph's display is based on the same technology as SIPS' other graphs windows, such as the Signal Display Window, thus it has features like automatic scaling of data into human-friendly values, an interactive tool-tip to display values, and customizable colours. However, the graph window does not need to be open to use the sediment analysis functionality.

VII. Automation

A notable advantage for some organizations has been the ability to create, share, recall, and apply process templates for performing work in SIPS. This allows for routine operations to be automated, and also permits organizations to standardize operations and workflows. The templates allow the user to set up any of the SIPS Processing tools and even determine their process order for maximum flexibility. The process template may be applied to one or more survey lines.

With the inclusion of Geocoder, the SIPS Template Wizard (STW) has been augmented to allow users to choose which processing engine they wish to use, Geocoder or SIPS. All process options available in the application are also available in the STW. Also, now that GeoBaRs are the target output of all processing in SIPS, the STW has provision to make these automatically. For convenience when creating new templates, the most recently used settings from Mosaic Editor will be the default values for the STW.

VIII. Conclusions

The integration of Geocoder in HIPS and SIPS has brought numerous benefits. Geocoder is the engine behind much of Mosaic Editor, with its correction, sediment analysis, mosaic creation and editing capabilities, making it a complete solution for backscatter processing and analysis. These new competencies, alongside the existing bathymetric and side scan processing, allows an organization to have one application and one overall workflow for all Bathymetry and Imagery post-processing needs. Efficiency and consistency can also be increased through the use of process templates. Altogether, this allows greater control and promotes quality through consistent processes.

The use of BASE Surface technology provides scalability and efficiencies in large data sets with CARIS' CSAR Framework. Storing Mosaics and GeoBaRs in Bathy DataBase provides the ability to share data between users, groups, offices; easily correlate mosaic imagery with bathymetry; restrict access to data; and provide traceability. Creating and retaining GeoBaRs means that originally processed data, i.e. not altered by the editing controls, is always available. Since the GeoBaR information is not lost, Mosaics can also be re-edited or recreated from the originally processed data.

Geocoder in CARIS HIPS and SIPS offers stability. CARIS is ISO 9001 certified and uses a standardized process approach to ensuring quality in software. CARIS' static and dynamic testing processes include Requirements, Design and Code Reviews; Unit, Integration, Regression, and Workflow testing; and a client Beta testing program.

By carefully integrating Geocoder with proven HIPS & SIPS technology, CARIS has met the challenges involved in bringing Geocoder to the commercial environment. Combining years of proven software, workflows, and data formats with innovative ideas and purpose-built interfaces, HIPS & SIPS maximizes the potential of Geocoder's processing and analysis.

IX. Future Work

Though there may be many small and medium enhancements to come, there are two major initiatives that are expected to be the centrepiece of the next version of SIPS. The first is the complete overhaul of the contact editing facility in SIPS. A new set of tools will be developed to make contact cataloguing smooth and intuitive. It is expected to have an intelligent contact correlation system, built on top of a relational database with customizable feature catalogues. It will also have the kinds of powerful but easy-to-use controls such as an interactive pan and zoom snapshot window, histogram controls, and simple measurement tools. This new tool will be integrated into Mosaic Editor and also allow for contact creation on GeoBaRs and mosaics rather being limited to the traditional waterfall approach.

The second major initiative is the ability to produce a new type of SIPS output product, an automated sediment classification map. Building on Geocoder's abilities and using existing CARIS technology, the sediment classification map will take the form of a mosaic with additional layers and attributes. It will also allow for integrated ground truth recording and provide options for a legend and other image formatting considerations. Leveraging both code bases most useful qualities in this area, the classification algorithm will be automated and efficient. This is expected to fully compatible with Bathy DataBase.

References

- Fonseca, L., and Mayer, L.A., 2007, Remote estimation of surficial seafloor properties through the application Angular Range Analysis to multibeam sonar data. *Marine Geophysical Researches*, p. 119-126. (Refereed Publication)
- Fonseca, L., and Calder, B., 2005, Geocoder: an efficient backscatter map constructor. *Proceedings of the U.S. Hydrographic Conference 2005*, San Diego, C.A.
- Masry, M., and Collins, C., 2008, Scaling Bathymetry: Data handling for large volumes. *Proceedings of the Shallow Survey Conference 2008*, Portsmouth, N.H.